# Cestodes
## The Tapeworms

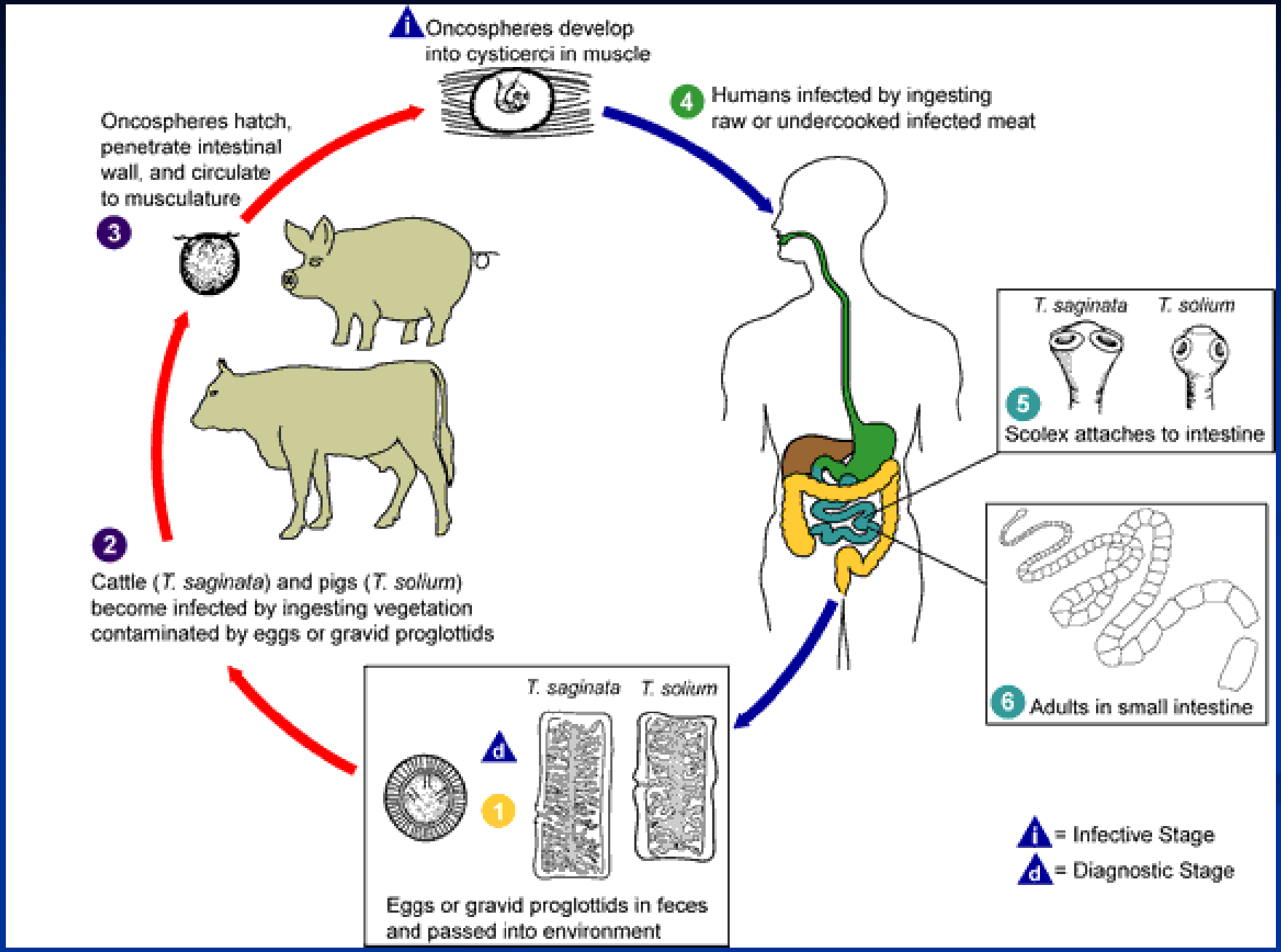
# *Taenia saginata* & *T. solium*

- *Taenia saginata* – Beef tapeworm
- *T. solium* – Pork tapeworm
- Worldwide distribution
- Humans acquire infection by ingestion of larval stage (cysticercus) in beef or pork
- Eggs of *T. solium* infective to humans & causes cysticercosis

# Cysticerci of *T. saginata* in beef

# *Taenia* Life Cycle

- Egg or proglottid shed in feces, ingested by cattle (T. sag) or pigs (T. sol), embryo (oncosphere) hatches & enters gut wall, filters out via circulation into musculature, develops to cysticercus (larval stage), ingested by human, evaginates and matures in gut
- PP 10-12 wks
- *T. solium* eggs INFECTIVE to humans
- *T. saginata* eggs NOT infective to humans


i
Oncospheres develop into cysticerci in muscle
4
Humans infected by ingesting raw or undercooked infected meat
Oncospheres hatch, penetrate intestinal wall, and circulate to musculature
3
T. saginata
T. solium
5
Scolex attaches to intestine
2
Cattle (T. saginata) and pigs (T. solium) become infected by ingesting vegetation contaminated by eggs or gravid proglottids
6
Adults in small intestine
T. saginata
T. solium
d
1
Eggs or gravid proglottids in feces and passed into environment
i = Infective Stage
d = Diagnostic Stage

# Proglottids in stool

# *T. saginata* vs *T. solium* Morphology

| | *T. saginata* | *T. solium* |
|---|---|---|
| **Size** | 5 – 25 meters | 2 – 7 meters |
| **Scolex** | Unarmed w/ 4 suckers | Armed w/ 4 suckers |
| **Gravid proglottid** | 15-20 uterine branches | 7-13 uterine branches |
| **Egg** | Thick striated shell, contains 6-hooked oncosphere, impossible to speciate | |

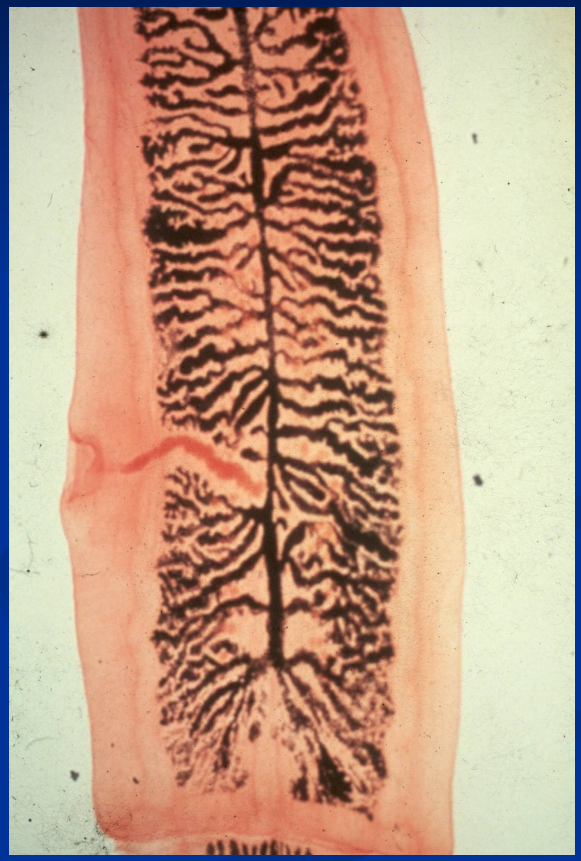
# *Taenia* eggs

# Scoleces of *T. solium* & *T. saginata*

*T. solium* w/ armed rostellum

*T. saginata* w/ unarmed rostellum

# *T. solium* vs *T. saginata* gravid proglottids



*T. solium* w/ 7-13 uterine branches

*T. saginata* w/ 15-20 uterine branch

# Taeniasis Intestinal Disease

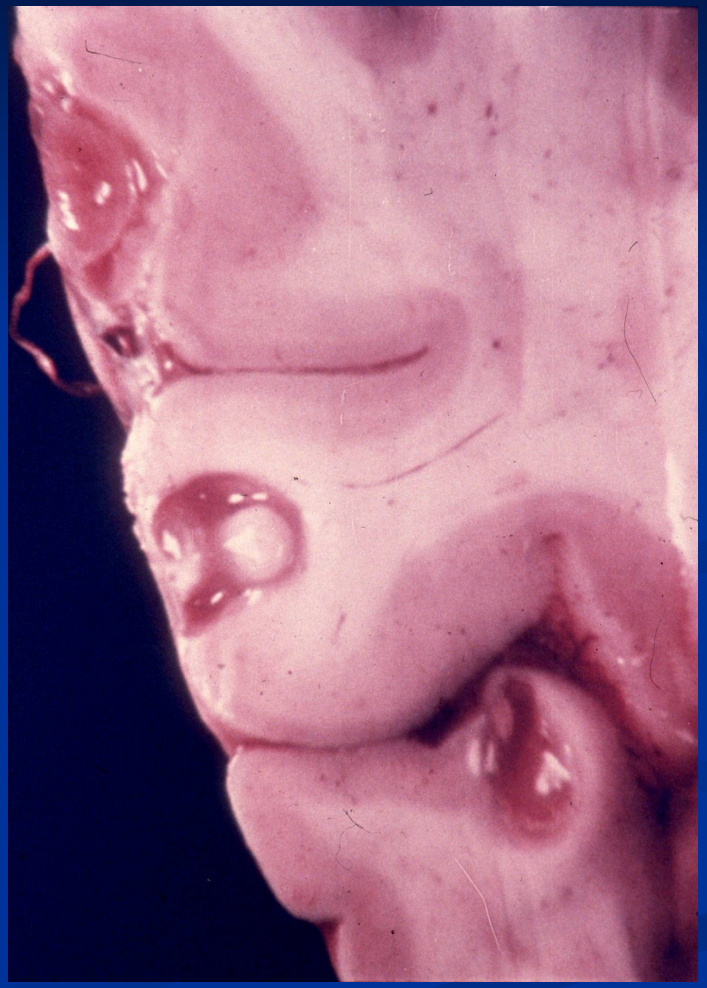
- Well tolerated, may cause diarrhea, weight loss, hunger pains
- Proglottids may crawl out anus at inopportune times
- ***T. solium* intestinal infection must be treated to avoid development of cysticercosis in patient & contacts**
- Tx w/ praziquantel 10mg/kg po single dose

# Cysticercosis Epidemiology

- Most common parasitic infection of the brain & most common cause of adult onset epilepsy
- Prevalent worldwide except Australasia
- In Peru, 12% of epileptic patients seropositive
- In Mexico, 0.1-3.5% seropositivity

# Cysticercus Morphology

- Fluid-filled bladder w/ single inverted scolex
- 1mm – 1cm
- Racemose cysts lack scolex, will grow to fill available space, & may be degenerative form, often causes fatal disease



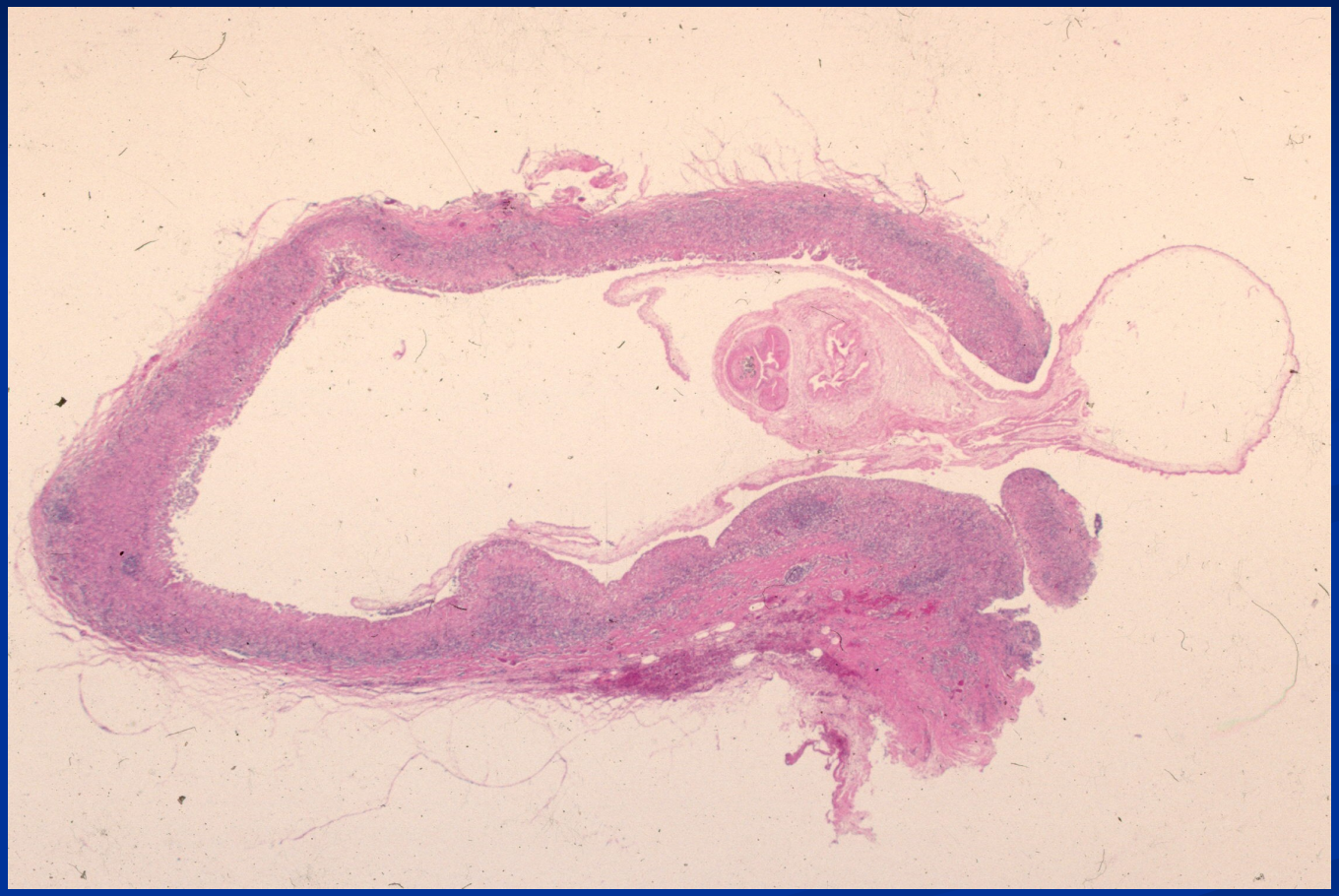
# Cysticercosis Disease

- Pathology dependent on number & location of cysts
- Viable cysts induce chronic lymphocytic & granulomatous inflammation that can last for years
- Dead/dying cysts induce acute inflammation, will eventually calcify

# Ocular, Muscular, & Cutaneous Cysticercosis

- Ocular
  - Cysts free in anterior or vitreous chamber, or attached to retinal tissue
  - Clouding, chorioretinitis, retinal detachment, edema, hemorrhage, disc vasculitis
- Muscular & Cutaneous
  - Occur anywhere
  - Inflammation, swelling, atrophy, calcification

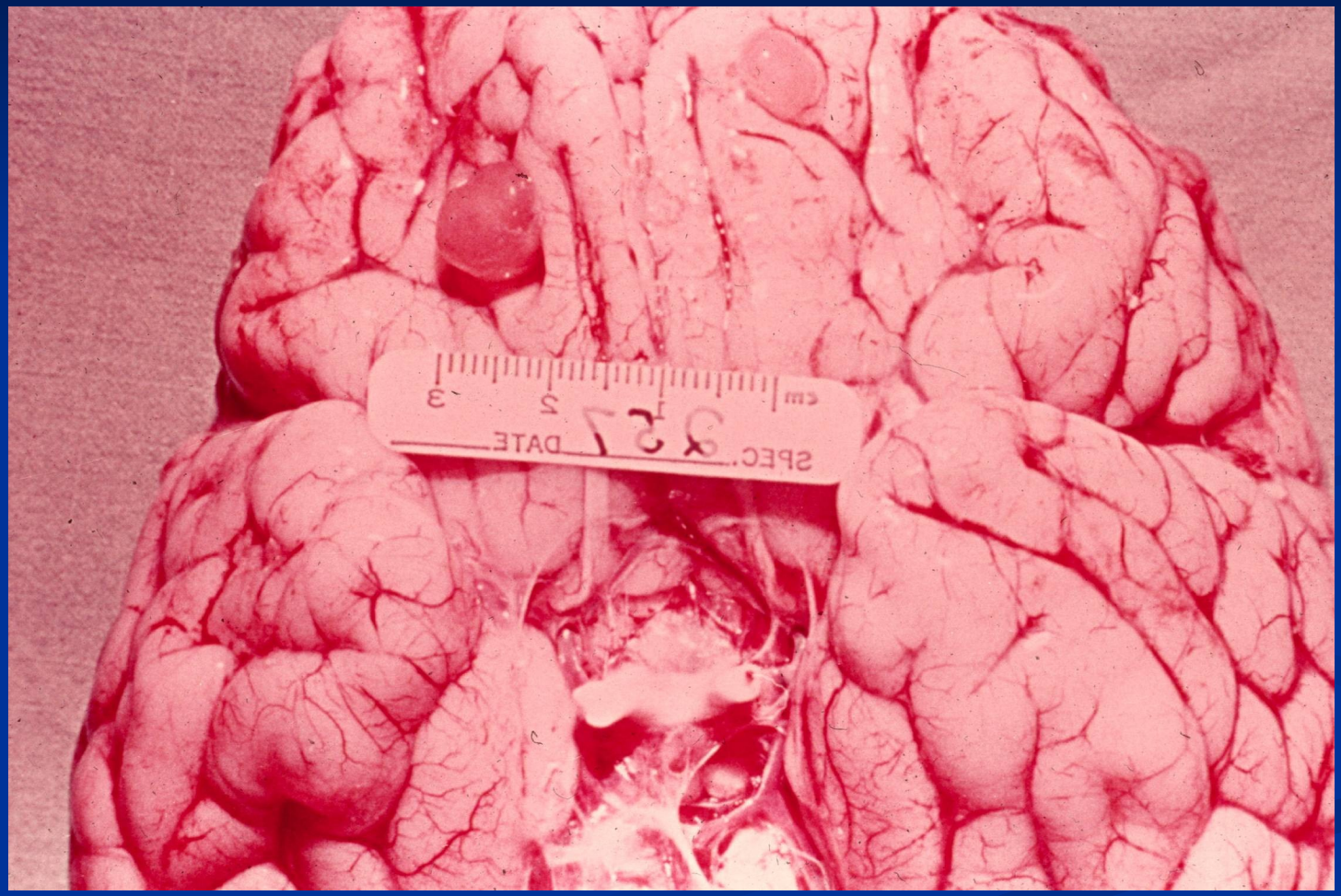
# Ocular cysticercosis in conjunctiva 2.5x



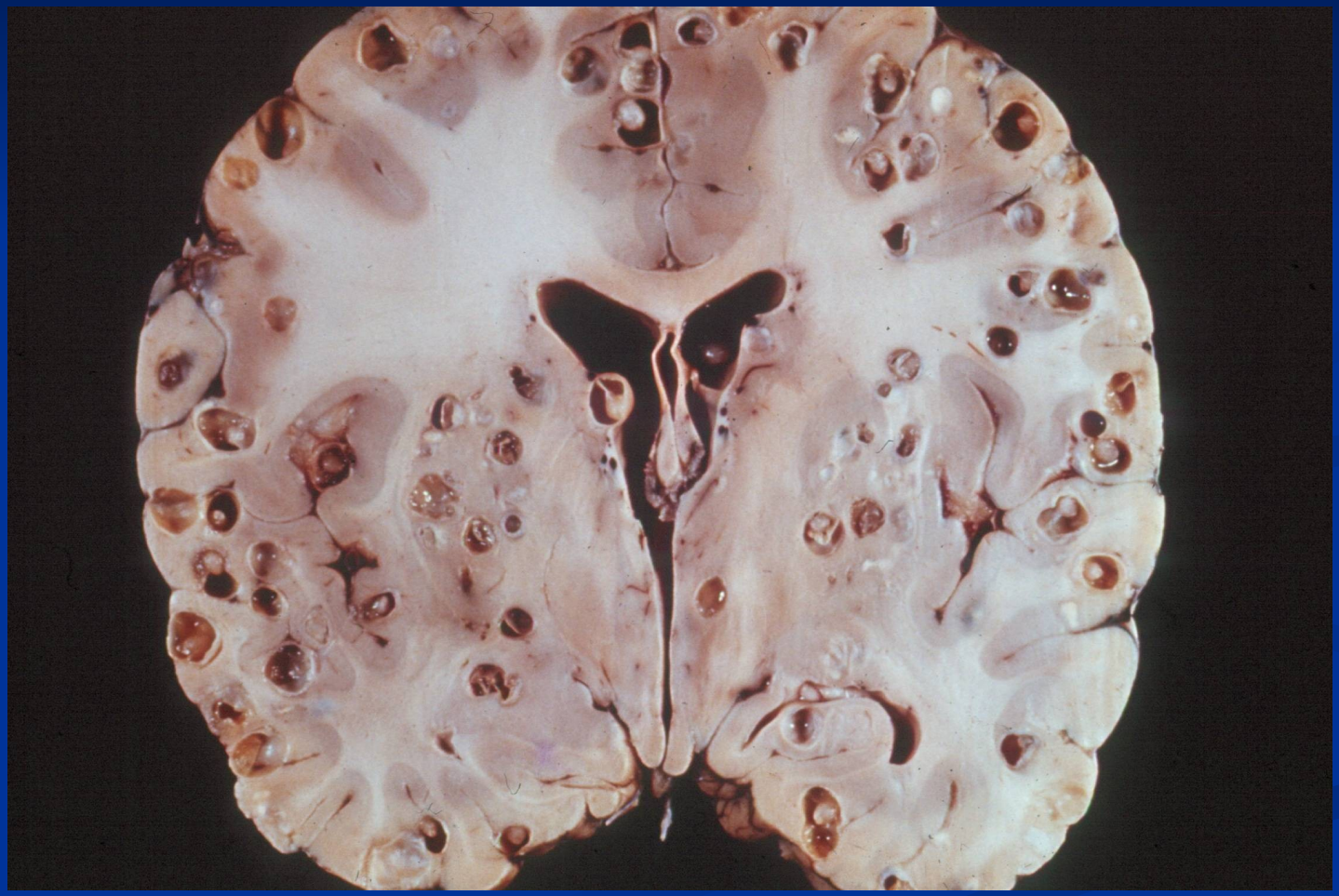
# Neural Cysticercosis

- Parenchymal cysts
  - Seizures, focal deficits, hypertension
- Meningeal cysts
  - Usually basal; hydrocephalus, arterial thrombosis, stroke
- Ventricular cysts
  - Asymptomatic unless CSF flow is blocked
- Spinal cord cysts
  - Arachnoiditis, mass lesion symptoms

# Cysticerci in brain



# Cysticerci in brain

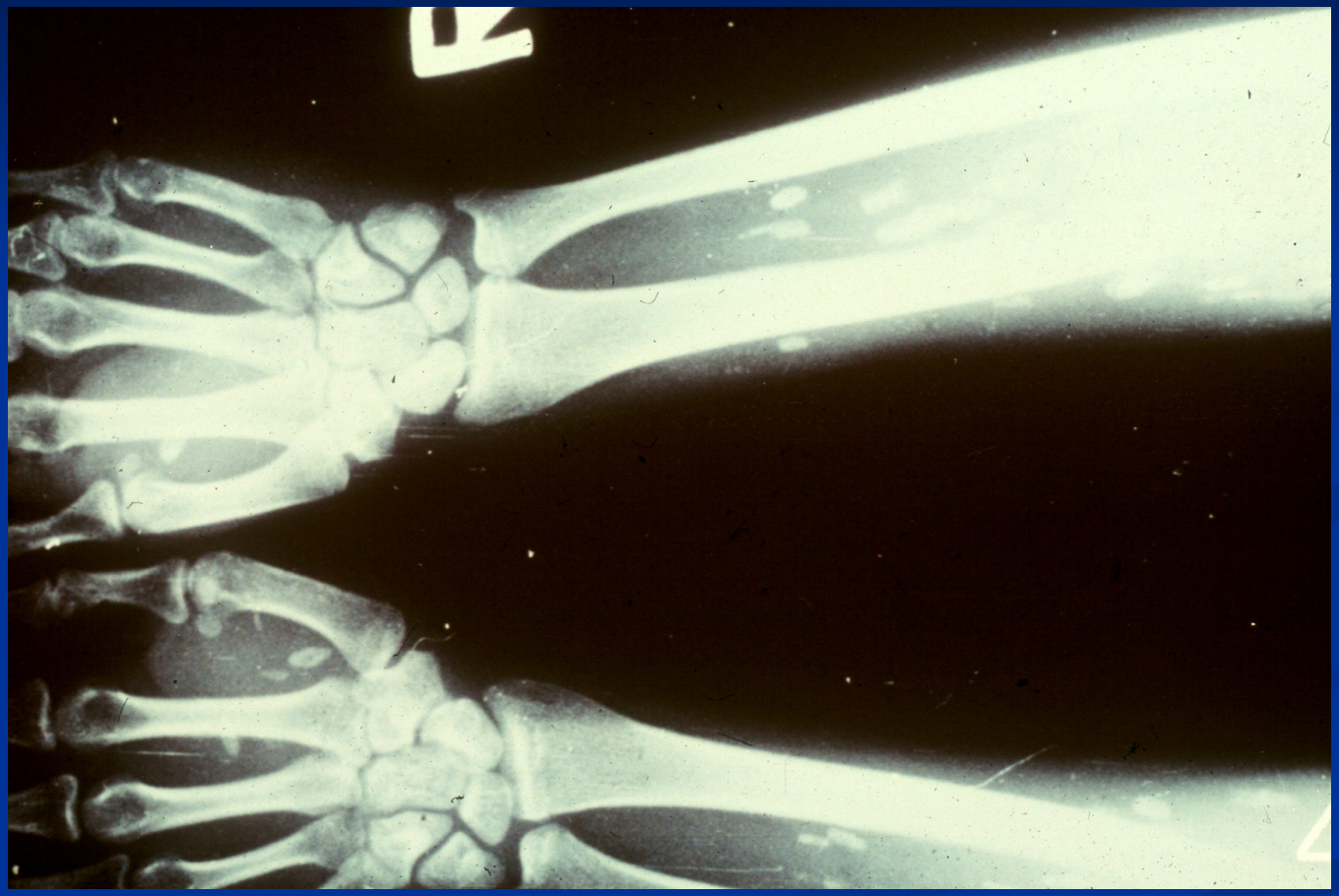


# Cysticercosis Diagnosis

- Biopsy
- Radiology will show calcifications
- CT scans show non-enhancing hypodense 5-10mm lesions, may reveal scolex
- Viable cysts non-enhancing, dying cysts enhancing, dead cysts usually calcified
- MRI
- EITB (enzyme-linked immunotransfer blot)

Garcia H et al, Clin Micro Rev 2002 15(4):747

# Calcifications on xray



# Cysticercosis Treatment

- Controversial; few controlled trials done to assess benefits of anticonvulsants alone or with antiparasitics

- General consensus:  use antiparasitics to kill viable cysts; dependent on number of cysts and location
  - Praziquantel (50-75 mg/kg/d po x 2wks) or albendazole (15 mg/kg po x 8-10d)

# Tx (cont)

- Calcified or enhancing lesions, if few, antiepileptics alone may suffice
- Neural & ocular disease, cysticerci death induces inflammation; give corticosteriods to control edema & hypertension if warranted
- Good reference: Garcia H. et al., Current Consensus Guidelines for Treatment of Neurocysticercosis. Clin Micro Rev 2002 15(4):747-756

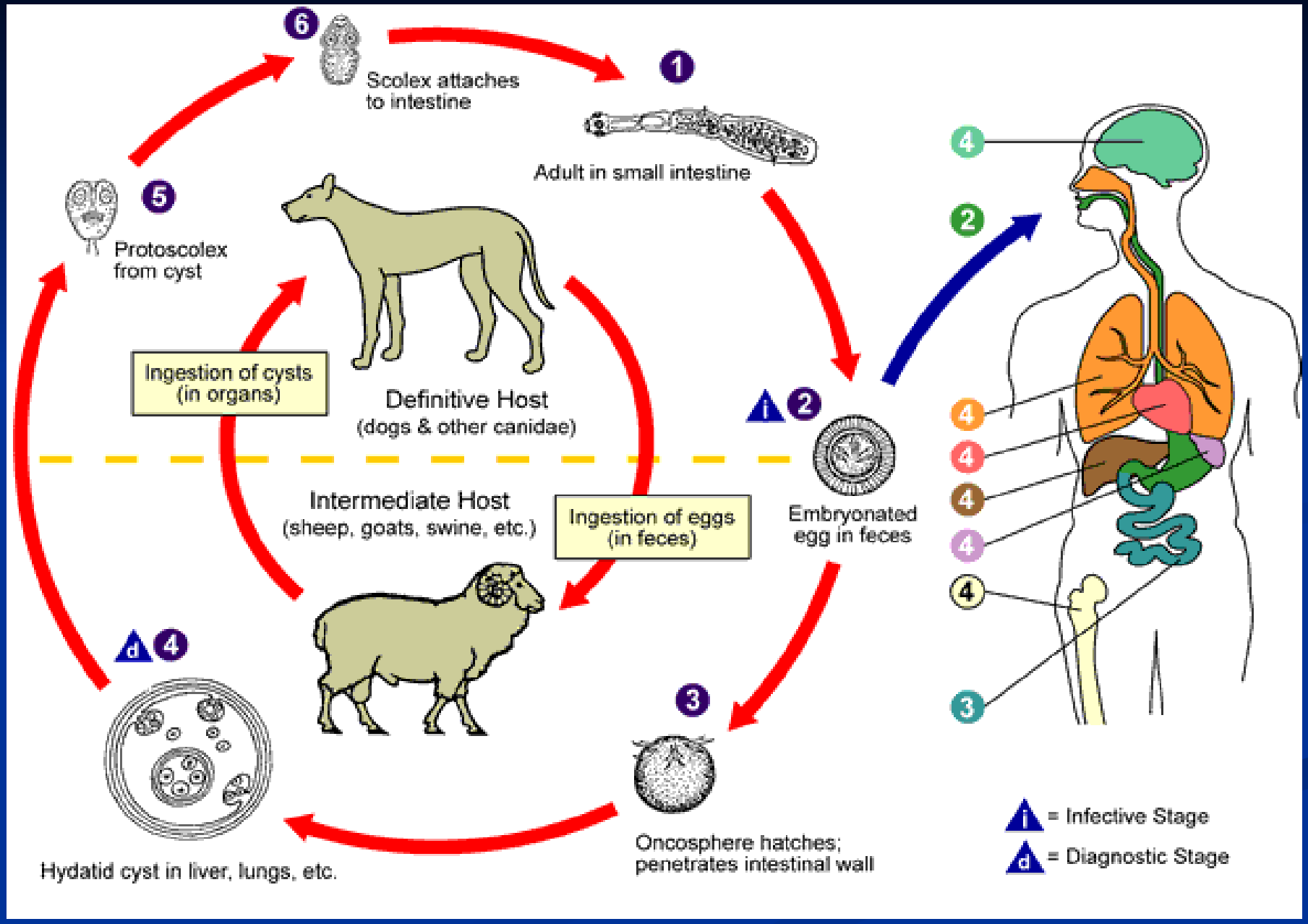
# Echinococcosis
## Hydatid Disease

# Epidemiology

- *Echinococcus granulosus* is usual the culprit (*E. multilocularis* & *E. vogeli* occasional agent)
- Cystic hydatid disease
- Worldwide, including Western hemisphere
- 3% prevalence in Peruvian highlands, spreading over Central Europe in red fox population
- Associated with dogs & sheep & other livestock or food/water contaminated with infective eggs

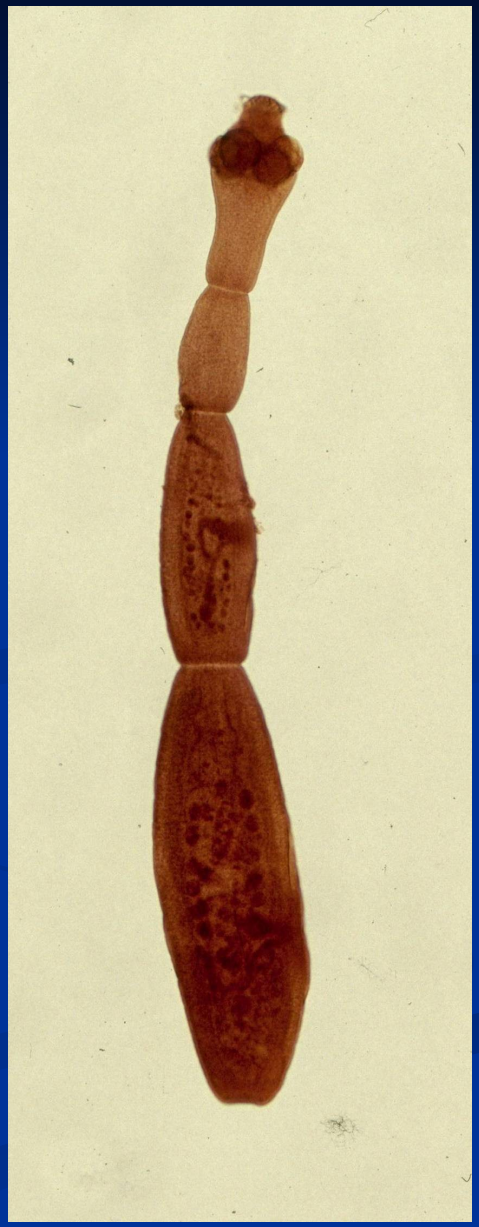
# Life Cycle

- Eggs from canid shed in feces
- Ingested by livestock
- Oncosphere passes through gut wall, filters out in tissue, becomes hydatid cyst
- Meat & offal ingested by canid
- Develops to adult in gut
- Humans acquire infection by ingesting eggs

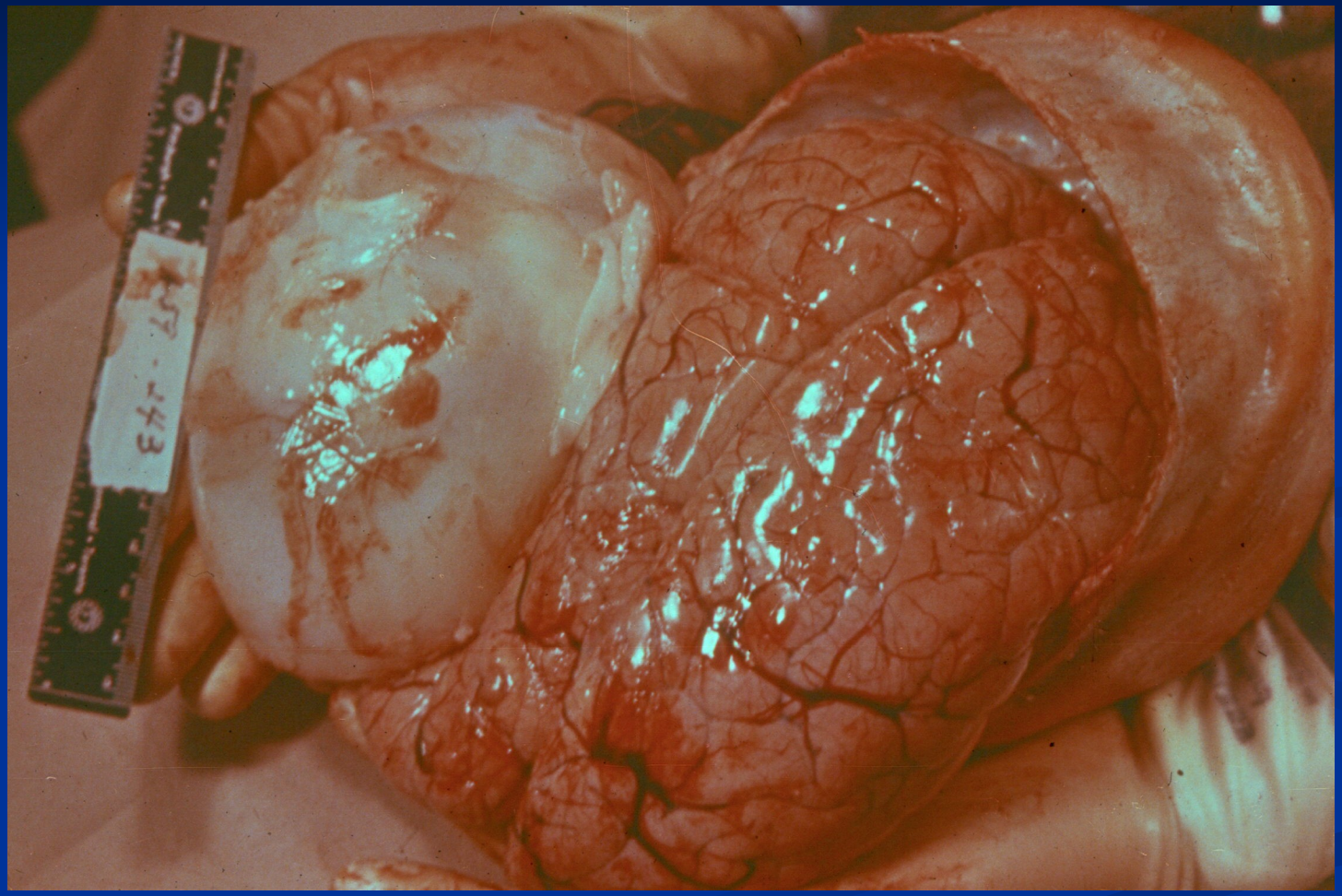

6
Scolex attaches to intestine
1
Adult in small intestine
5
Protoscolex from cyst
Ingestion of cysts (in organs)
Definitive Host
(dogs & other canidae)
i 2
Embryonated egg in feces
Intermediate Host
(sheep, goats, swine, etc.)
Ingestion of eggs (in feces)
d 4
Hydatid cyst in liver, lungs, etc.
3
Oncosphere hatches; penetrates intestinal wall
4
2
4
4
4
4
4
3
i = Infective Stage
d = Diagnostic Stage

# Morphology

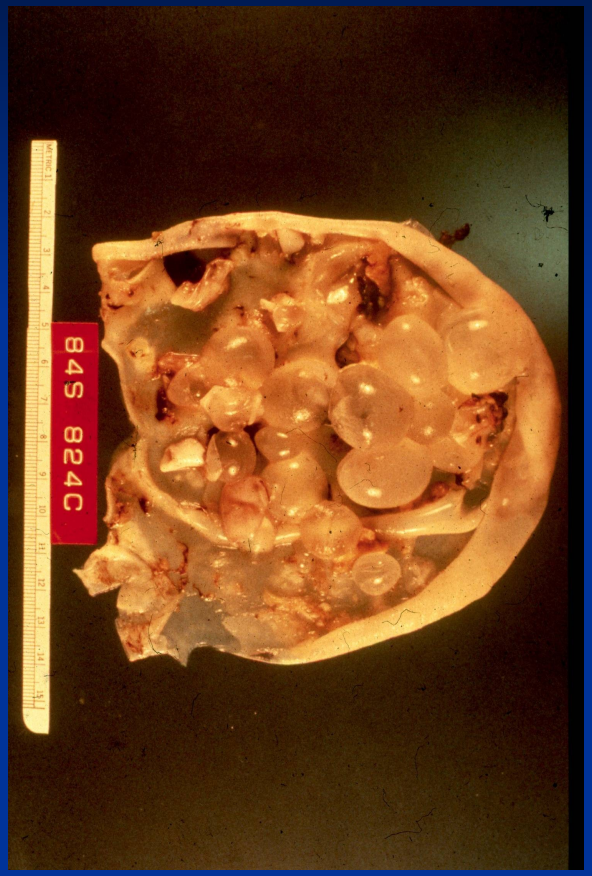
- Adults 3-6 mm, 3 proglottids
- Eggs look like *Taenia* eggs
- Hydatid cyst
  - Single large cyst up to 20 cm w/ 2 liters of fluid containing hydatid sand (contains scoleces & capsules)
  - Brood capsules grow from germinal layer on inside cyst wall
  - Each capsule filled with numerous scoleces

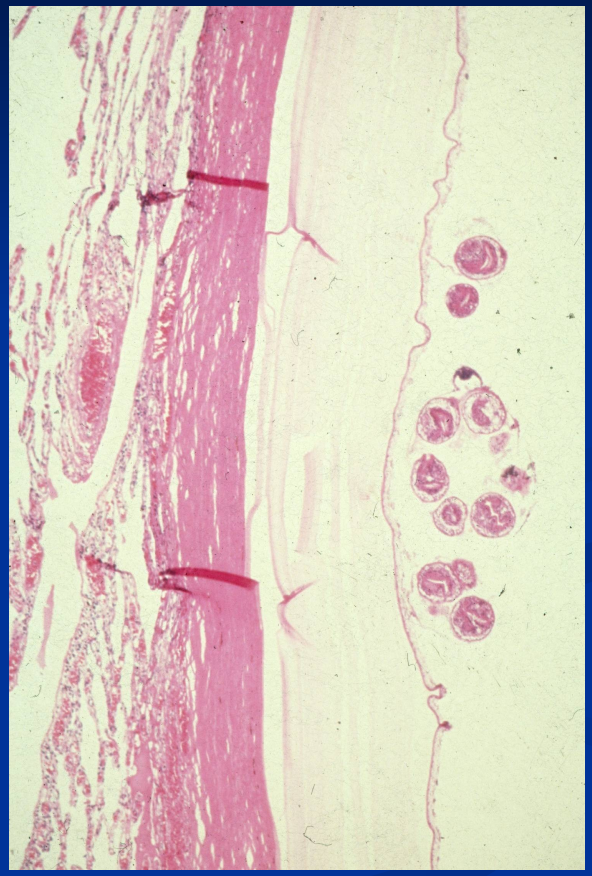


# Hydatid Cyst



# Cyst morphology



Germinal layer with brood
capsule containing new scoleces

# Hydatid sand

- Fluid inside a hydatid cysts containing free scoleces, brood capsule debris, waste products

# Cystic Hydatid Disease

- IP 2-20 years
- Cysts usually in liver, lungs, spleen, kidneys, heart, bone, peritoneum, CNS
- Asymptomatic until size causes dysfunction
- If ruptured
  - Severe anaphylactic shock
  - Scoleces released & can disseminate everywhere
- Pressure effects & mechanical damage
- Occasional leakage can disseminate scoleces

# Cystic Hydatid Disease Dx & Tx

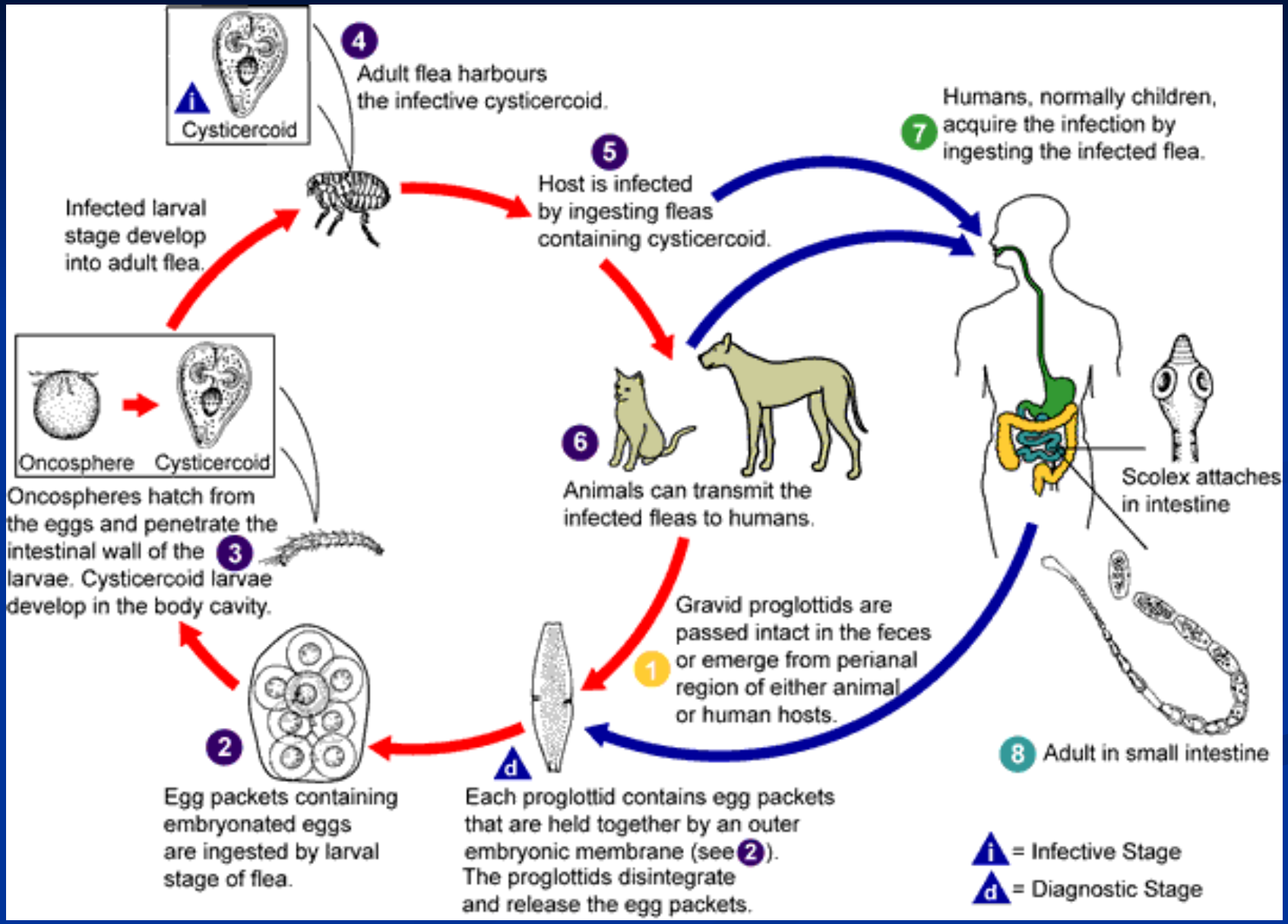
- Ultrasound & CT
- EITB, serology available from CDC
- Albendazole 400 mg po bid x 28d; pediatric 15 mg/kg/d divided bid x 28d
- Aspiration and/or surgical removal with care to avoid spillage of scoleces (first sterilize cyst w/ hypertonic saline, ethanol, or 10% formalin)

# Minor Cestodes

# *Dipylidium caninum* – Dog Tapeworm

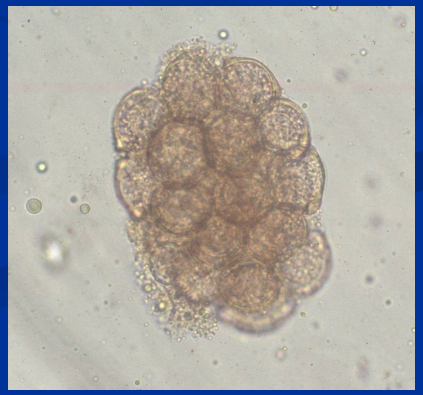
- Worldwide distribution
- Normal cycle is dog-flea-dog
- Humans acquire infection from ingestion of the larvae within a flea
- PP 1 month
- Usually asymptomatic, mild GI disturbances can occur
- In pets, pruritis caused by proglottid migration induces behavior to relieve itching (dragging anal area over grass or carpeting)

# *D. caninum* lifecycle


i
Cysticercoid
4
Adult flea harbours the infective cysticercoid.
5
Host is infected by ingesting fleas containing cysticercoid.
7
Humans, normally children, acquire the infection by ingesting the infected flea.
Infected larval stage develop into adult flea.
Oncosphere
Cysticercoid
Oncospheres hatch from the eggs and penetrate the intestinal wall of the larvae. Cysticercoid larvae develop in the body cavity.
3
6
Animals can transmit the infected fleas to humans.
Scolex attaches in intestine
Gravid proglottids are passed intact in the feces or emerge from perianal region of either animal or human hosts.
1
2
Egg packets containing embryonated eggs are ingested by larval stage of flea.
d
Each proglottid contains egg packets that are held together by an outer embryonic membrane (see 2). The proglottids disintegrate and release the egg packets.
8
Adult in small intestine
i = Infective Stage
d = Diagnostic Stage

# *D. caninum*

- Adults 60 cm long
- Proglottids
  - 12 mm
  - Double-pored proglottids
  - Shed individually and migrate from anus or are shed in feces
  - Highly motile & active (may be mistaken for maggots when passed)
  - Resemble sesame seeds or rice
- Eggs
  - Contain 6-hooked oncosphere
  - Usually seen in packets of 5-15 eggs
  - 35-40 µm
- Treatment with praziquantel 5-10 mg/kg once or niclosamide 2 g once (pediatric 50 mg)



# Trematodes

## The Flukes

# Schistosomes infecting humans

- *Schistosoma mansoni*
- *S. japonicum*
- *S. haematobiun*
- *S. mekongi*
- *S. intercalatum*
- *S. mattheei*
- *S. malayensis*

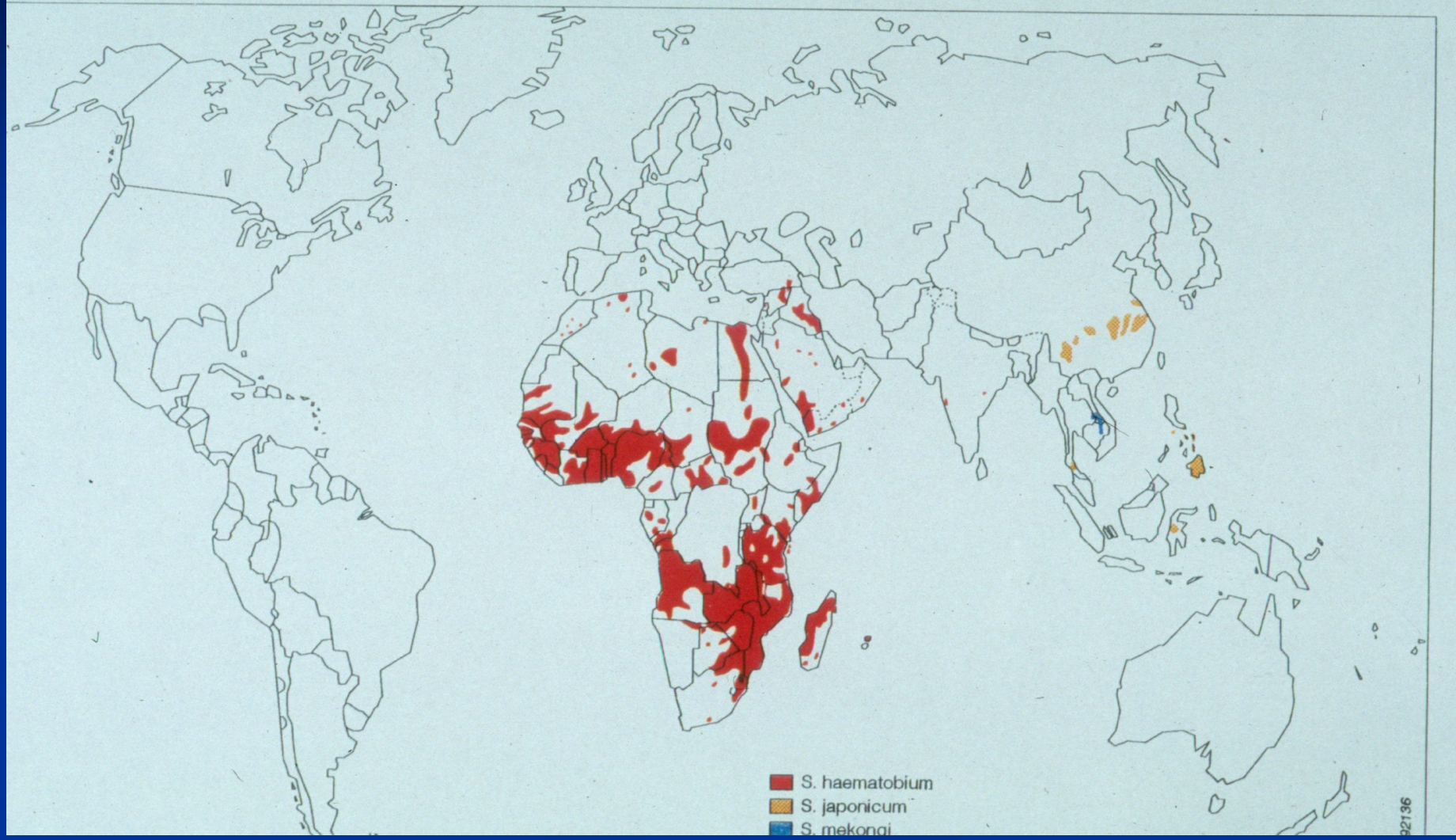
# Epidemiology

- 200 million infected in 77 countries
- Transmission from person – snail – person via fresh water
- Acquired via skin penetration by cercariae after release from snail
- Increase in prevalence associated with agricultural development & irrigation, increasing population
- Animal reservoirs important with *S. japonicum*

# Geographic Distribution

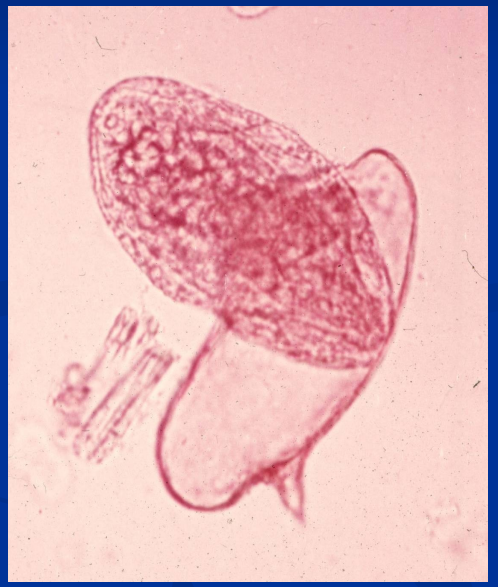
- *S. mansoni* – Africa, Middle East, Venezuela, Suriname, Brazil, Caribbean
- *S. japonicum* – China, Philippines, Japan, Indonesia
- *S. haematobium* – Middle East, Africa (esp. Nile Delta)
- *S. mekongi* – Mekong Delta
- *S. intercalatum* – West Africa
- *S. mattheei* – Southern Africa
- *S. malayensis* - Malaysia

Fig. 2 Global distribution of schistosomiasis due to Schistosoma haematobium, S. japonicum, and S. mekongi



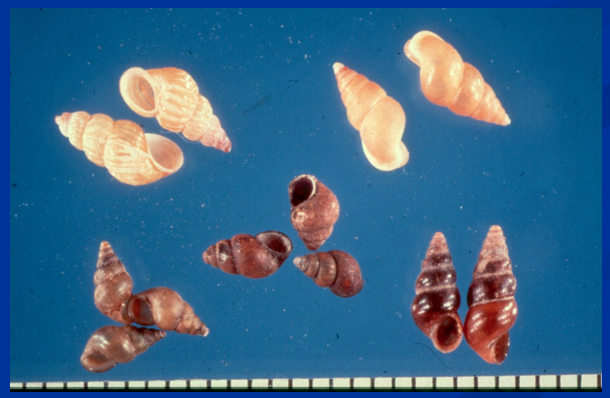
# Generalized Life Cycle

- Eggs are shed via feces into water
  - Exception is *S. haematobium* eggs which are shed in urine
- Miracidia hatch & enter snail intermediate hosts
- Develop to actively motile fork-tailed cercariae which exit snail
- Enter human skin & lose tails to become schistosomula

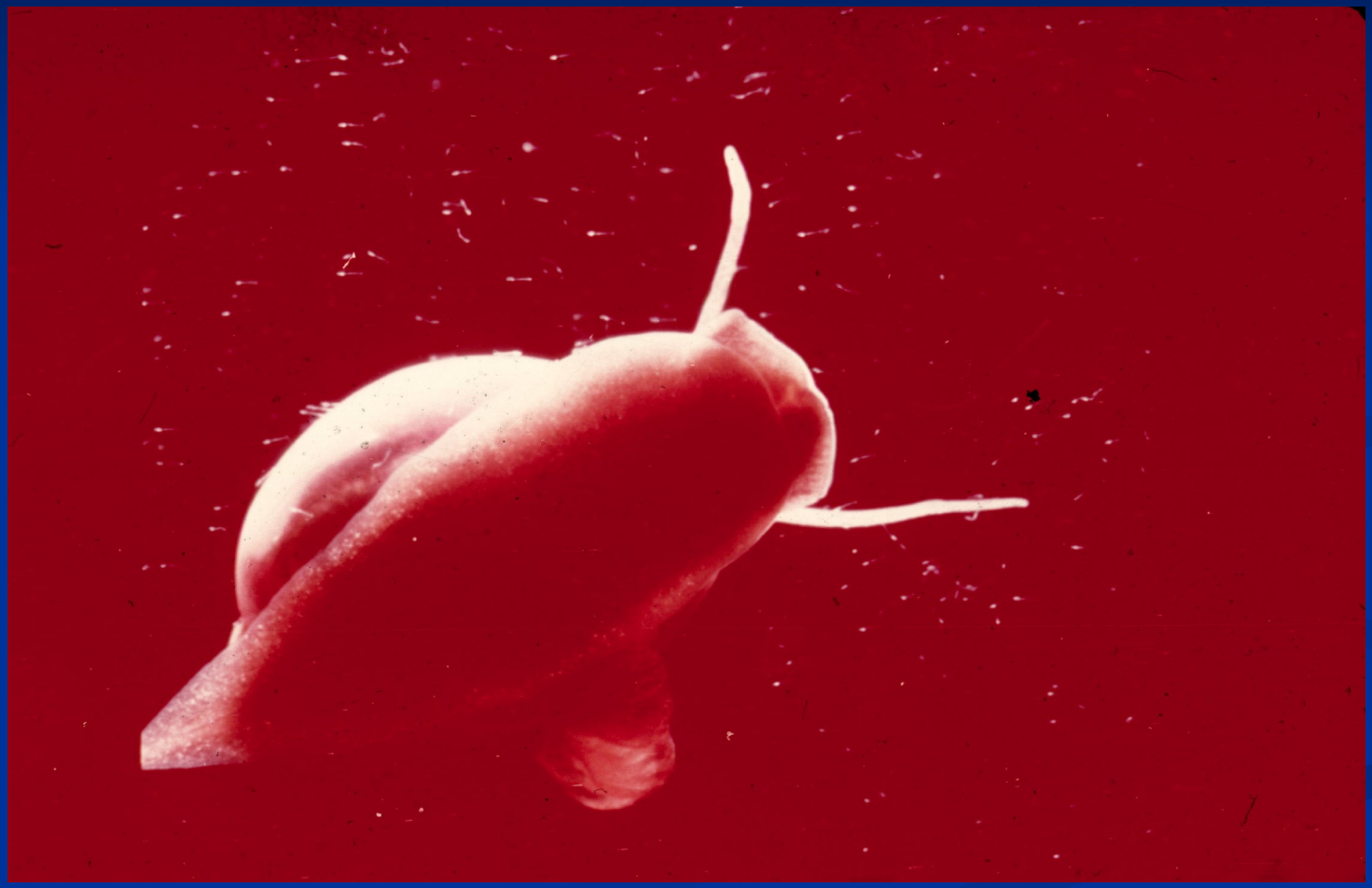


# Schistosome intermediate hosts

- Sm – *Biomphalaria* spp. aquatic snails
- Sj – *Oncomelania* spp. amphibious snails
- Sh – *Bulinus* spp. aquatic snails (not shown)



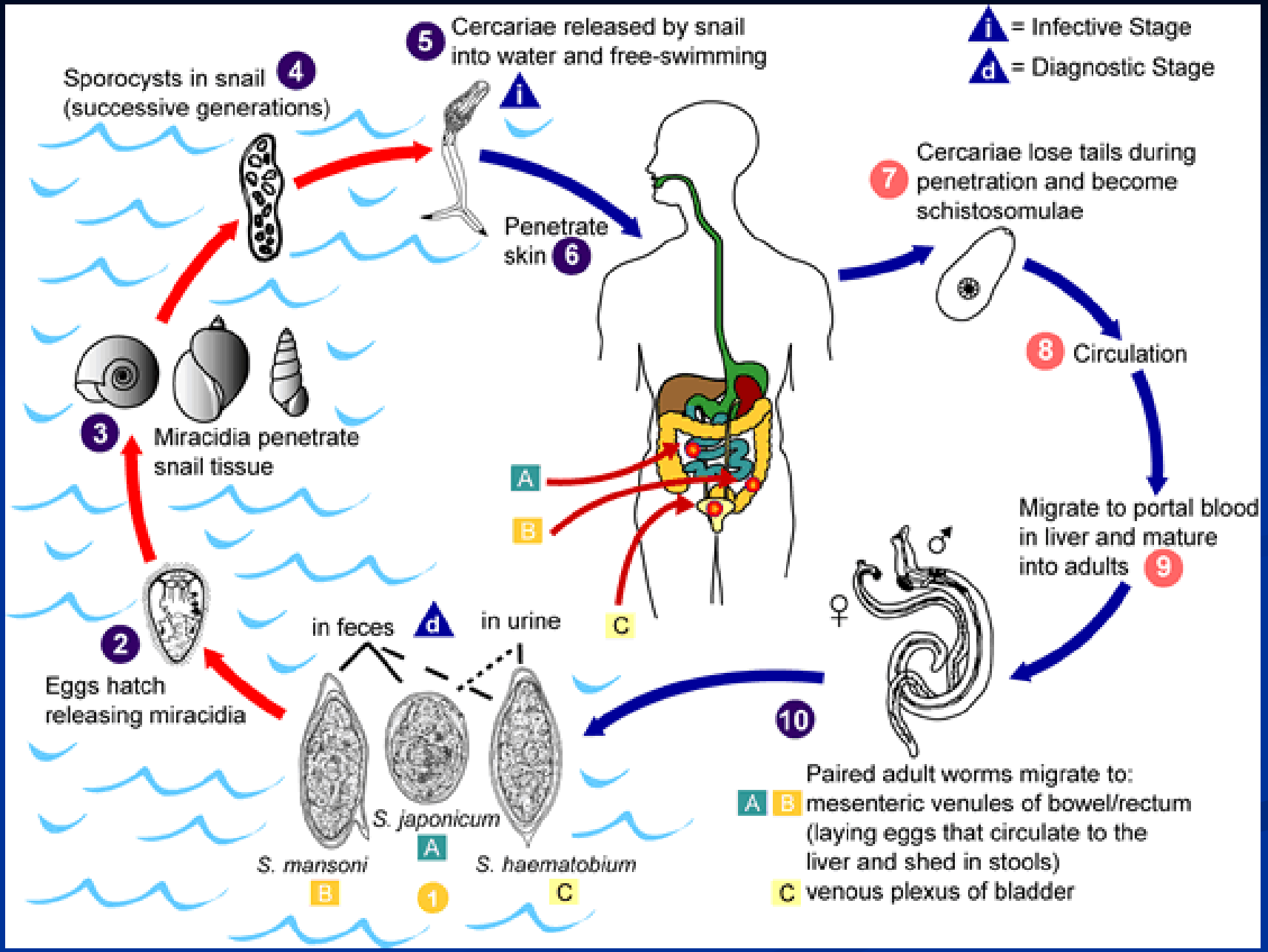
# *Biomphalaria* shedding cercariae



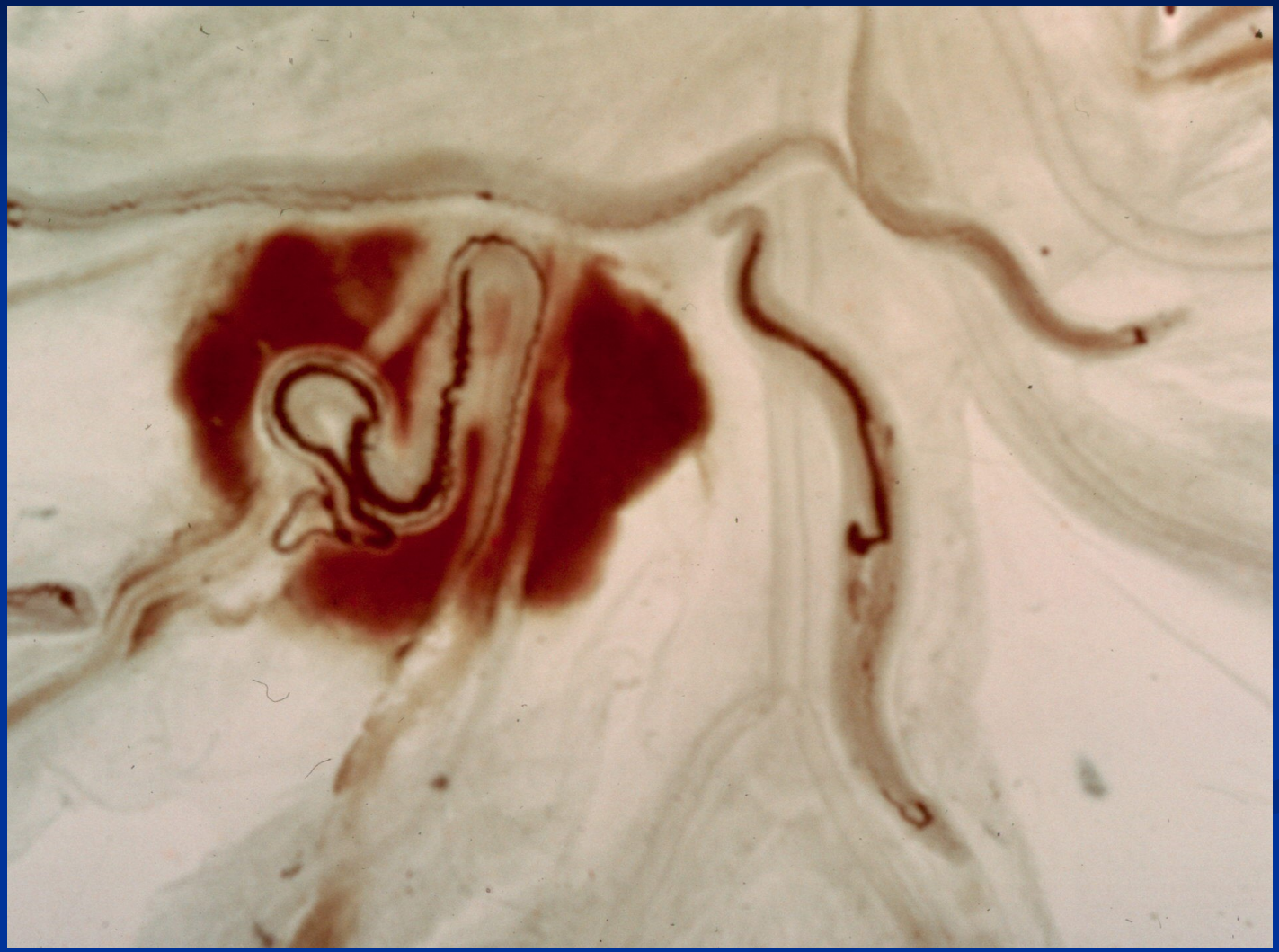
# Fork tailed cercaria – enters skin

# Life cycle (cont.)

- Migrate via venous blood thru heart & lungs to final habitat, mate
  - Sm – inferior mesenterics
  - Sj – inf. mesenterics & superior hemorrhoidal
  - Sh – vesicular, prostatic, rectal & uterine plexi
- Produce eggs which migrate to intestinal or bladder lumen and exit host
- Paired adults can live many years


i = Infective Stage
d = Diagnostic Stage
1 Cercariae released by snail into water and free-swimming
2 Eggs hatch releasing miracidia
3 Miracidia penetrate snail tissue
4 Sporocysts in snail (successive generations)
5
6 Penetrate skin
7 Cercariae lose tails during penetration and become schistosomulae
8 Circulation
9 Migrate to portal blood in liver and mature into adults
10 Paired adult worms migrate to:
A B mesenteric venules of bowel/rectum (laying eggs that circulate to the liver and shed in stools)
C venous plexus of bladder
in feces
in urine
S. japonicum
S. mansoni
S. haematobium
A
B
C

# Paired adults in situ

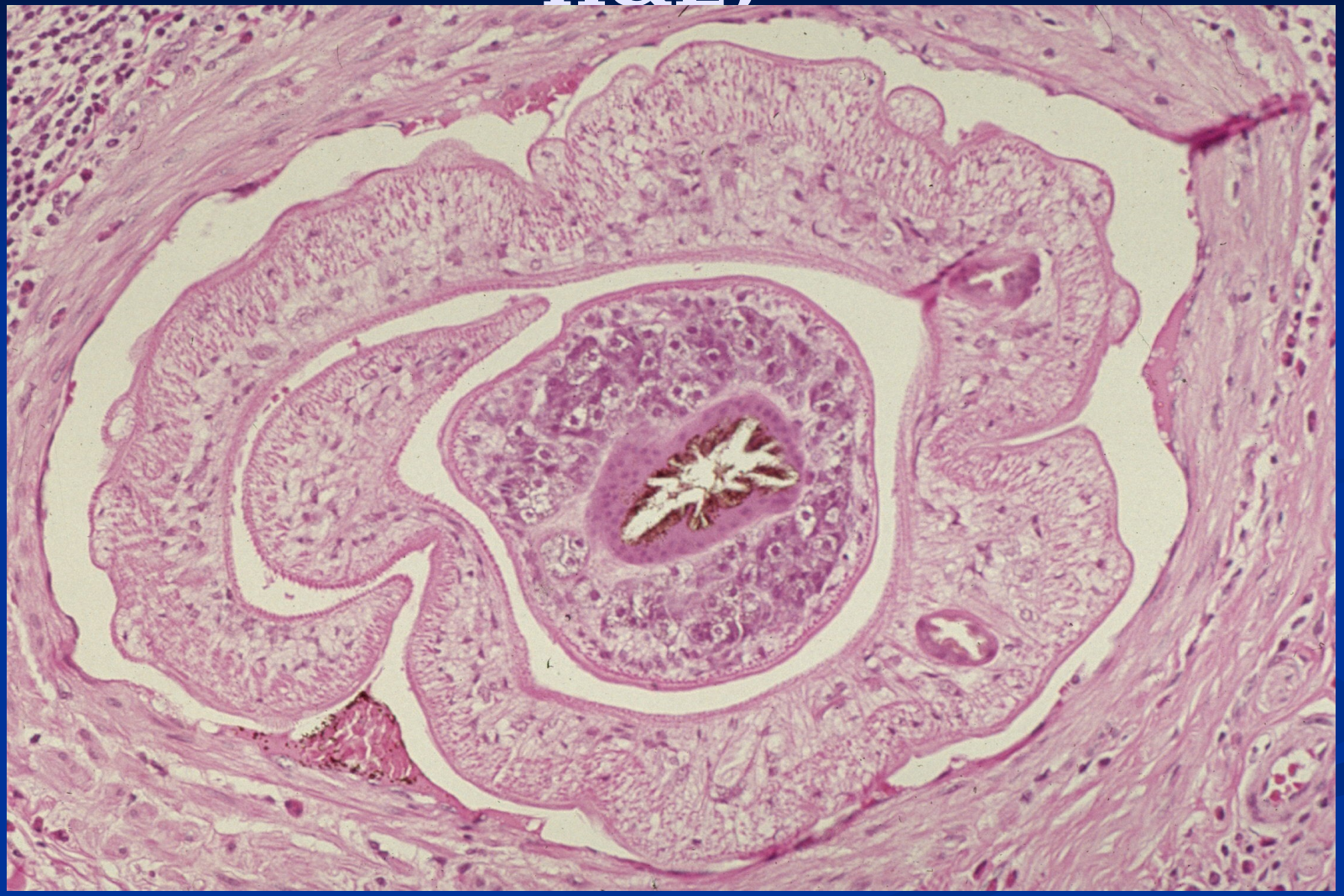


# Morphology

- Adults
  - Males 6-12 x 1-1.2 mm, females 7-17 x 0.16 mm
  - Male w/ gynecophoral canal within rests the female
  - Only trematode in humans with separate sexes
- Eggs
  - Embryonated – contain miracidium
  - Only trematode eggs from humans *without* an operculum
  - Have single spine helpful in diagnosis

# *S. japonicum* adults

# *S. mansoni* adults (45x H&E)



# Egg Morphology

| Species | Size in µm | Spine |
|---|---|---|
| ***S. mansoni*** | 115-175 x 45-70 | Large, lateral |
| ***S. japonicum*** | 70-100 x 55-65 | Small, lateral |
| ***S. haematobium*** | 155-170 x 40-70 | Large, terminal |
| *S. intercalatum* | 140-240 x 50-85 | Large, terminal |
| *S. mekongi* | 50-80 x 40-65 | Small, lateral |

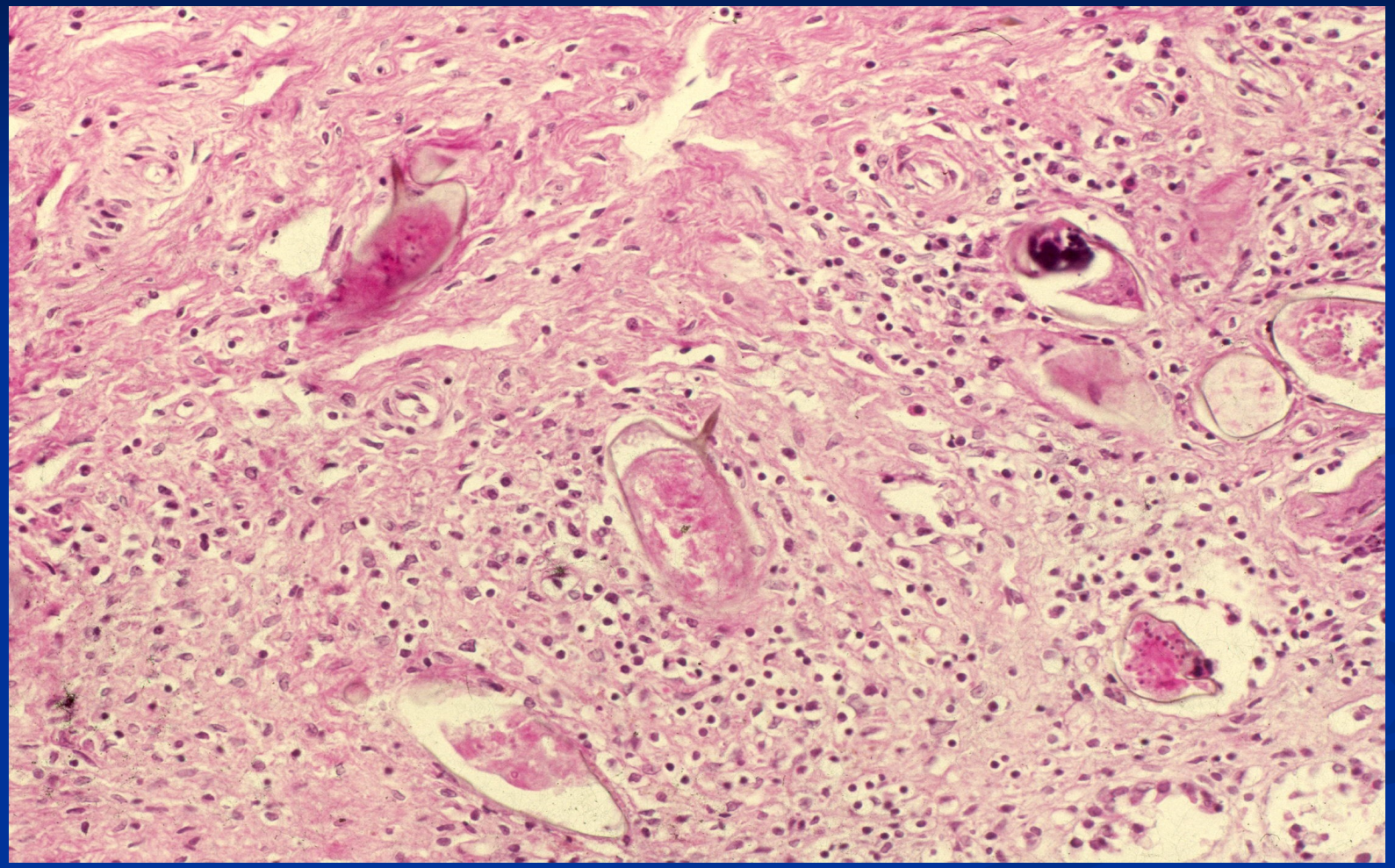
# Quiz!!  Wooohooo!

# Pathology

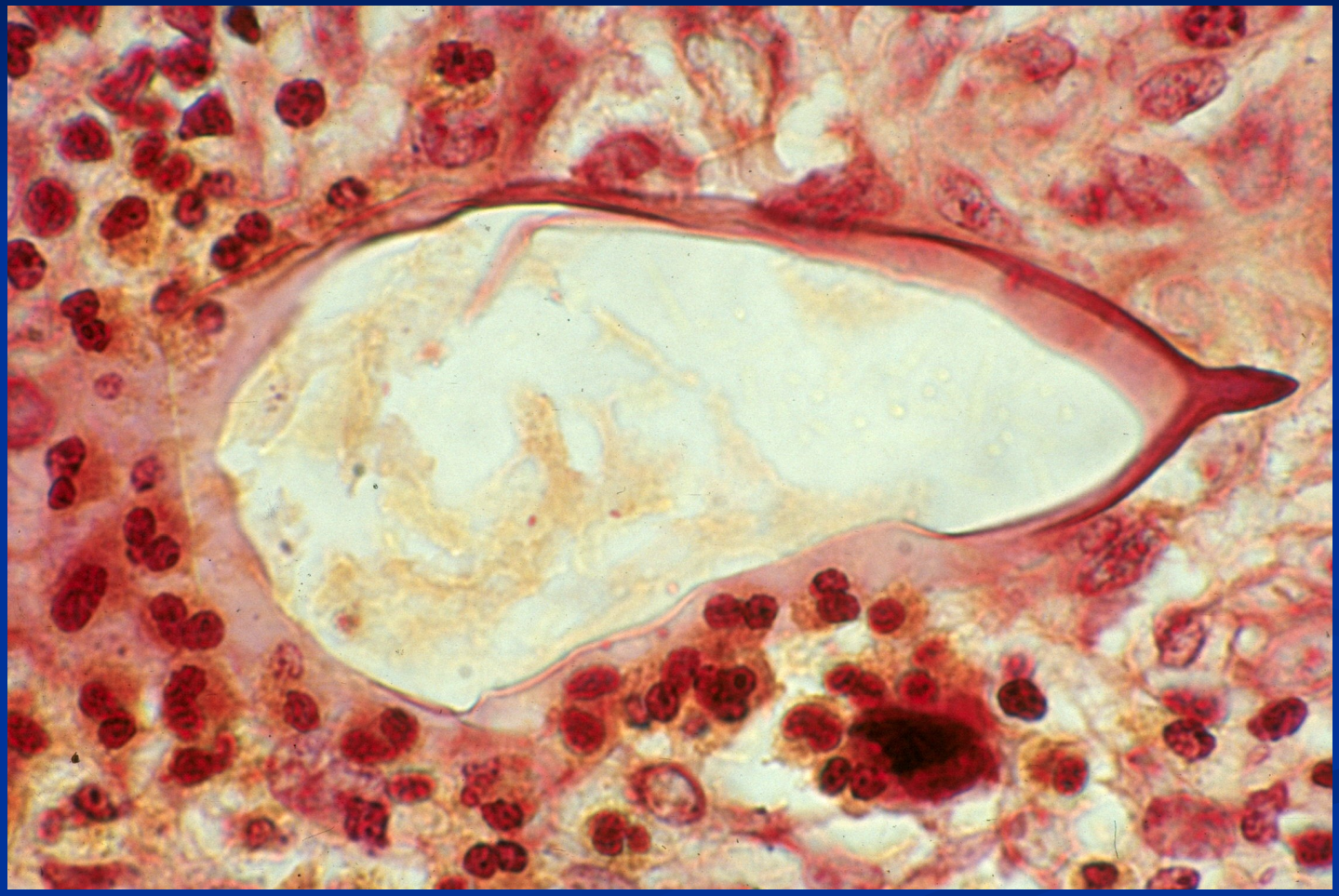
- Granuloma formation around eggs is primary cause of most disease associated with chronic schistosomiasis

- Eggs can embolize to other locations: lungs, CNS

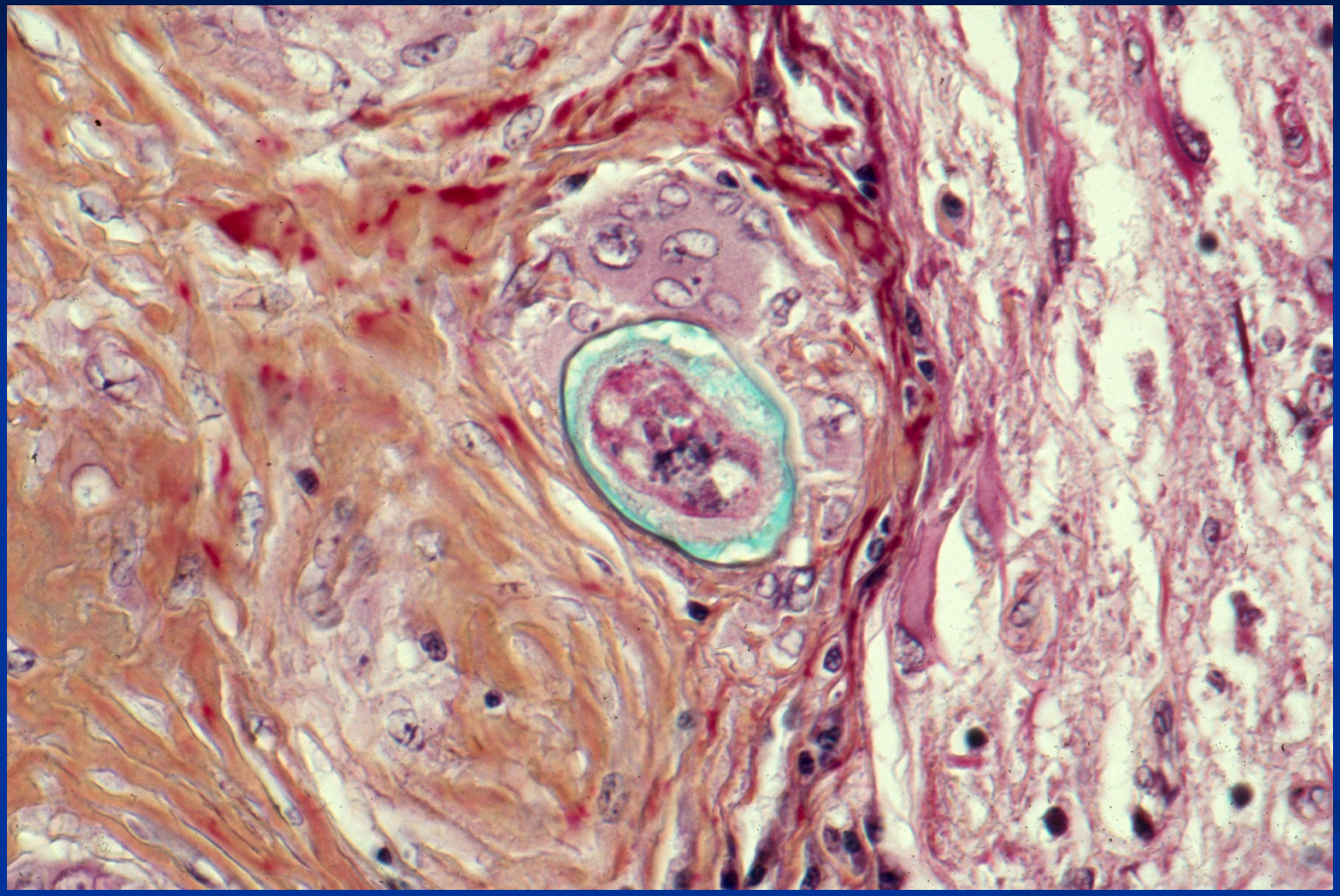
# Colon (50x H&E)



# Appendix (250x B&H)



# Brain (400 x Movat)



# Clinical – Acute Stage

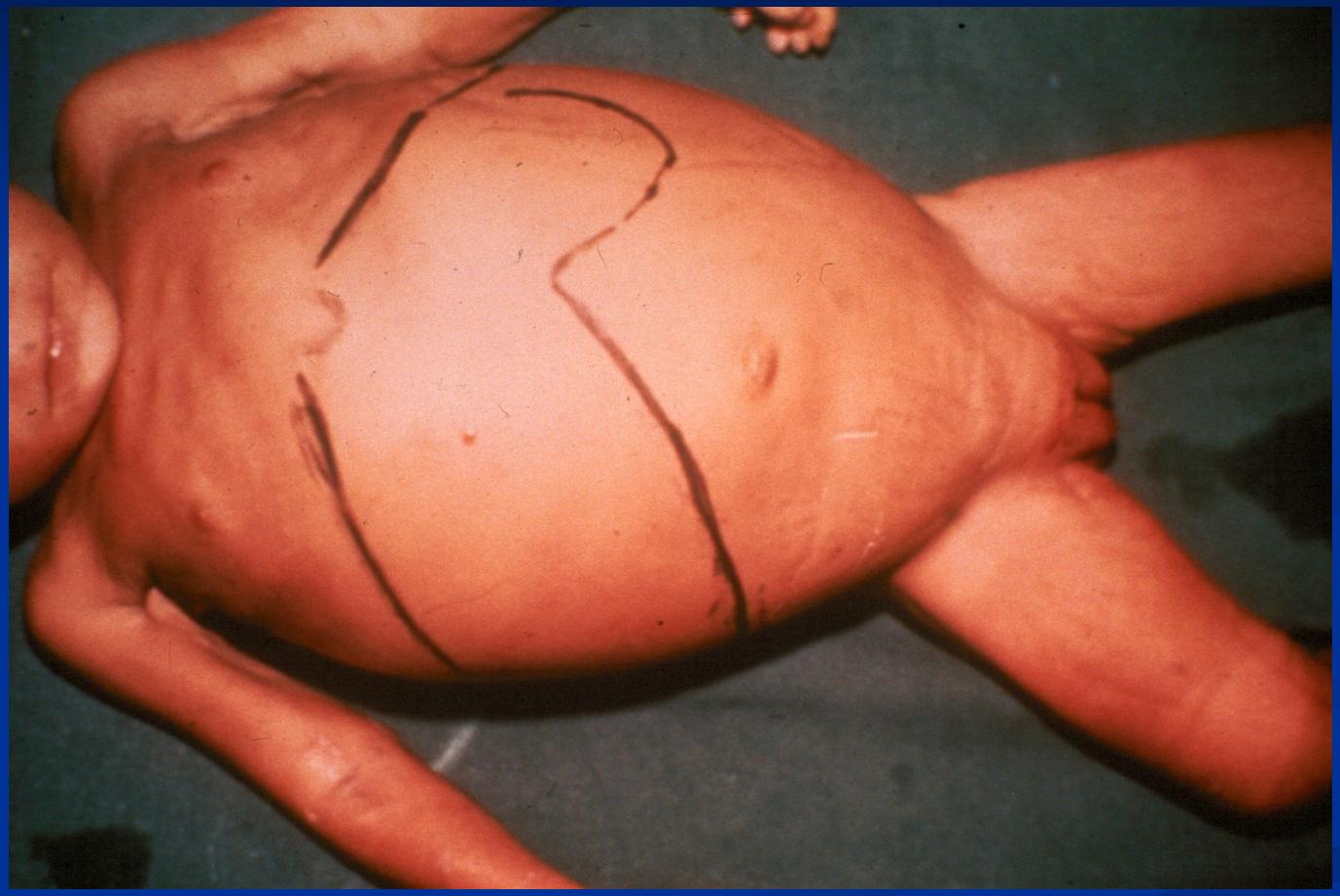
- Katayama Syndrome
  - IP 4-7 wks, during time of first egg release and formation of immune complexes
  - Immunologically naïve patients
  - Sudden onset of fever, chills, weakness, weight loss, headache, anorexia, nausea, vomiting, diarrhea, abdominal pain, tenesmus, myalgia, arthralgia, dry cough, hepatomegaly, eosinophilia (10,000/ul)

# Clinical – Chronic Stage

## *S. mansoni* & *S. japonicum*

- May not become patent for decades
- Signs & symptoms of focal granulomatous large bowel disease
- Abdominal pain, bloody stool, malaise
- Hepato & splenomegaly
- Portal hypertension, ascites
- Esophageal varices
- Intestinal granulomatosis & polyposis (*Sm*) in small portion of Middle Eastern patients

# Hepatomegaly



# Hepato & splenomegaly from *Sm*

# Clinical – Chronic Stage
## *S. haematobium*

- Dysuria, terminal hematuria, urinary frequency
- Obstructive uropathy
  - Pyelonephritis, renal failure
- Chronic bacteriuria
- Bladder carcinoma
- Calcification

# Treatment

- Praziquantel is treatment of choice
  - 20 mg/kg po bid x 1d
- Metrifonate sometimes used against *S. haematobium* – 10 mg/kg po q2 wks x 3
- For praziquantel resistant *S. mansoni*
  - Oxaminiquine 15 mg/kg po
  - N&E Africa – 20 mg/kg po x 3d

# Diagnosis

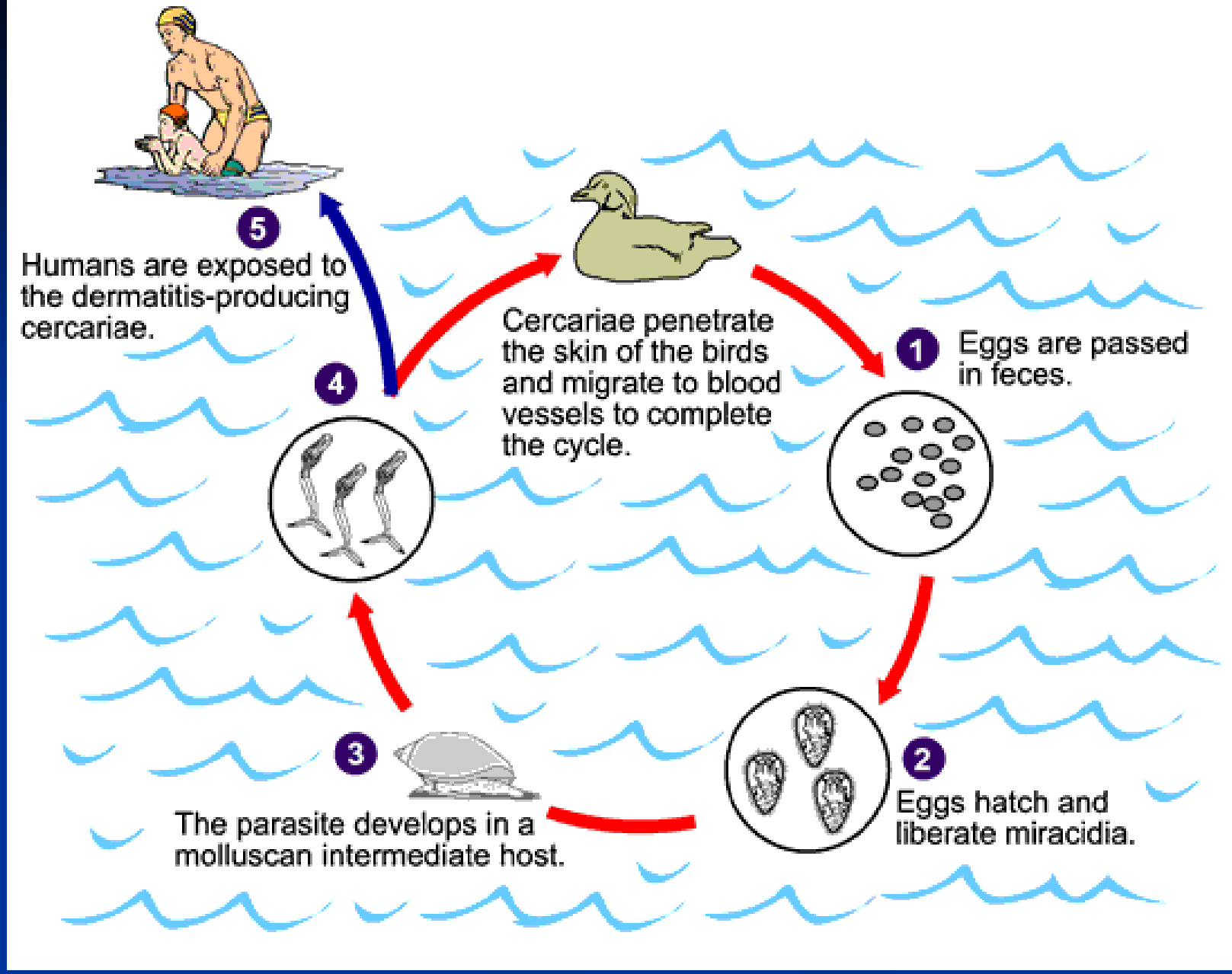
- ID of eggs in stool or urine
  - Quantification & viability
    - Kato thick smear – 50 mg feces squashed through 105 mesh steel sieve onto slide, covered w/ glycerin impregnated cover slip, 1-2 days fecal material will clear leaving eggs.
- ELISA, Immunoblot Ab detection tests
- Ag detection and rapids – dipstick assays against circulating antigens (CCA)

# Prevention & Control

- Public education
- Keep feces & urine away from public use bodies of water
- Separate water used for drinking, bathing or treat with iodine, chlorine or filtration
- Keep irrigation ditches free of snail intermediate hosts – clearing, molluscicides
- Mass chemotherapy campaigns

# Cercarial dermatitis - Swimmer's Itch

- Skin penetration by cercaria, usually of zoophilic origin, esp. avian forms
- Sensitization reaction, increased severity with increased exposure
- Pruritic urticarial rash with onset ranging from minutes (repeated exposure) to days
- Lasts several days to few weeks
- Macular, papular, vesicular, pustular stages
- Treatment palliative


5
Humans are exposed to the dermatitis-producing cercariae.
4
Cercariae penetrate the skin of the birds and migrate to blood vessels to complete the cycle.
1
Eggs are passed in feces.
3
The parasite develops in a molluscan intermediate host.
2
Eggs hatch and liberate miracidia.

# Swimmer’s Itch

**By Johnell Kolve, Image # Swimmer_Itch_1_031127; in DermAtlas.org**

# Sooo…..what's there left to do?

- Waterborne:
  - Schistosomes, Dracunculiasis
- Aquatic vegetation or crustaceans:
  - Flukes other than Schistosomes
- Soil
  - Hookworm & Strongy (skin), Whipworm, Ascaris, VLM, CLM
- Foodstuffs (meats, fish, cereals)
  - Trichinosis, anisakiasis, Tapeworms
- Arthropods
  - Filariasis, Dipylidium, Hymenolepis spp.